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A METHOD FOR THE CONTROL OF COTTON ROOT ROT IN THE IRRIGATED SOUTHWEST

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INTRODUCTION

Root rot is the most destructive disease of cotton in the United States. It also attacks with varying degrees of severity more than 300 species of economic plants and more than 400 uncultivated plants. From an economic standpoint it is, therefore, one of the most important plant diseases known. It has been estimated that it causes crop losses in Texas amounting to 100 million dollars annually.¹ In seven other States in which it occurs (fig. 1) it effects annual losses which probably exceed 50 million dollars.

Root rot is caused by a fungus (*Phymatotrichum omnivorum* (Shear) Duggar) which lives in the soil and attacks and destroys the roots of susceptible plants. The fungus is native to the Southwest and is frequently found on the roots of plants even in the driest sections of Arizona and southern California. It appears to thrive best in regions with high summer temperatures and in soils that are alkaline in reaction; it does not extend into the region of acid soils east of the Mississippi River (fig. 1).

DESCRIPTION OF THE DISEASE

In the Southwestern States root rot usually appears in cotton fields about the middle of June. The fungus often becomes active in the soil as early as April or May, but does not destroy many plants until more extensive mycelia are developed. The first symptom of the disease to be observed on the plants above the ground is a slight yellowing or bronzing of the foliage. This is followed by sudden wilting of the leaves and shortly afterward death of the plants. Neighboring plants rapidly become infected and soon ex-

¹TAUBENHAUS, J. J., and EZEKIEL, W. N. RECENT STUDIES ON PHYMATOTRICHUM ROOT ROT. Amer. Jour. Bot. 17: 554-571, illus. 1930.

tensive spots of blackened dead plants appear in the fields in striking contrast to the intervening areas of green healthy plants.

The fungus usually makes its attack on the taproot of the plant, a few inches below the surface of the ground. In the initial stages necrotic small sunken areas are produced, which are dark brown in color and are separated from the healthy tissues by a reddish-brown border. At this stage the mycelium of the fungus may be seen on the surface of the roots as a whitish or buff-colored growth which is frequently more abundant at the lenticels, where it appears as whitish tufts. A little later, as growth of the fungus continues, coarser and more complex filaments are developed which appear on the roots as yellowish or brown strands. The infection soon involves the greater portion of the root system, and the bark becomes loosened and easily slips from the woody cylinder, which is the last portion of the root to decay.

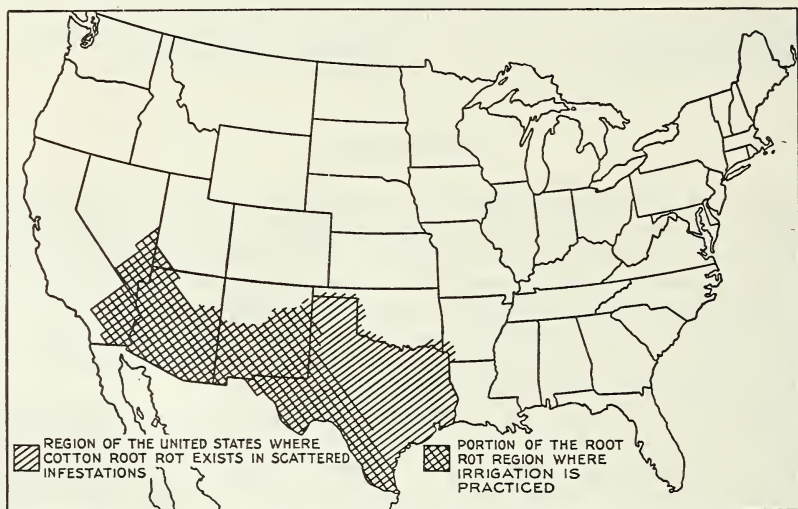


FIGURE 1.—Map showing region of the United States where cotton root rot exists in scattered infestations.

PROPAGATION AND SPREAD

Under favorable conditions the root rot fungus may survive from one season to another on the roots of infected plants. It also has a sclerotium, or resting stage, by which it maintains itself in the soil until conditions are again favorable for its growth. The sclerotia are variable in size and shape, but usually are round or egg-shaped, and range in size from that of a mustard seed to a kernel of wheat. They are whitish or buff-colored when first formed, but become reddish brown and finally almost black with age. Enlarged sections of strands also may be sclerotial in character and help to perpetuate the disease in much the same way as the rounded structures.

Experiments have shown that sclerotia may remain alive in the soil for at least 3 or 4 years, even in the absence of susceptible plants. It is because of their hardiness that the disease is able to persist in the

same spots for many years. The presence of sclerotia in the soil may be determined by a simple method of washing soil samples through sieves with water and examining the residues on coarse sieves. In infested cotton fields of the irrigated region they have been found by this method to exist in colonies or "pockets" concentrated mostly at depths of 10 to 30 inches.

The fungus makes its appearance above ground only when developing fruiting bodies. These appear, when conditions are favorable, in the form of cushionlike mats bearing spores. At first the mats are creamy white in color, but they soon turn pinkish buff and then brown. Sometimes new growth continues around the edges of the mats until a diameter of a foot or more is attained. Most commonly they are found on the outer margins of diseased areas after cloudy or rainy periods from May to October. The spores do not germinate readily, and it seems unlikely that they play an important part in disseminating the disease.

The root rot fungus spreads in cotton or alfalfa fields in a radial manner, killing the plants in ever-widening circles. The spots where all the cotton plants are killed in one season may break up into several spots or may disappear in subsequent seasons and later recur irrespective of cultural treatment.

Continuous mapping of diseased areas over a period of years in cotton fields has shown that in annual crops the disease is more or less restricted to certain areas. While it may extend through the soil into marginal areas, apparently it is not readily transferred by surface means. However, it is known that the disease may be started in new places by the transfer of infected roots and by soil containing sclerotia and strands of the fungus; hence any practice involving transfer of soil or rooted plants from infested localities should be avoided.

MISCELLANEOUS CONTROL METHODS

A large number of methods have been tried in the effort to control root rot, but none of them has been satisfactory for the entire region where the disease is economically important. In Texas, a 2- or 3-year rotation of cotton with grain crops, combined with deep tillage after the grain is harvested, has reduced the disease to some extent. Many soil disinfectants have been tried in attempts to eradicate the disease in small areas. Solutions of formalin in dilutions of $1\frac{1}{4}$ to 2 percent and of ammonia 2 to 4 percent were found beneficial in checking the disease when introduced into infested soil. However, disinfectants are effective only where the solution can reach the fungus, and under some conditions this is not practicable. Various kinds of barriers have been developed to limit the spread of the disease. The most effective of these were trench barriers containing mixtures of soil and heavy oils, ammonia, sulphur, and salt.

CONTROL BY ORGANIC MANURES

A cultural method developed in Arizona has proved effective in controlling the disease in cotton grown under irrigation. It requires continued treatment over a period of years, but the treatment is practicable for nearly all conditions and is beneficial to the soil aside from its effects in reducing the disease. The method consists of applications of various organic materials in deep furrows during the fall

and winter, and in planting the cotton over the buried material. The furrows for the manure should be from 10 to 14 inches deep so that the buried material will not interfere with the preparation of a seed-bed. For preparing the furrows a lister plow or middlebuster may be used, or a moldboard plow may be set for great depth and a return trip made in the same furrow to clean out a suitable trench. Tractor equipment is best suited for preparing the furrows, but team-drawn implements are usually satisfactory if the soil is not too heavy and refractory.

The aim, according to previous findings,² of applying organic matter is to increase the populations of bacteria, fungi, and other saprophytic organisms within the soil. Therefore, sufficient organic matter should be added to induce maximum microbiological activity without producing serious toxic or retarding effects on the seedling cotton plants. This quantity will depend somewhat on the composition of the manures and the amount of readily decomposable materials contained therein, as well as on the type of soil, amount of soil moisture or irrigation available, etc.

It has been found that as much as 20 tons of horse or cow manure from corrals or open stalls per acre may be used without injury to the cotton crop. However, 15 tons per acre probably would be adequate for most conditions. Where green material such as freshly cut alfalfa, clover, field peas, vetch, or mustard is available, 30 tons per acre may be used if furrows are made deep enough so that the material may be covered with 5 or 6 inches of soil (fig. 2). Ordinarily this amount of green material represents about 10 to 12 tons of dry matter, and if it is necessary to use spoiled hay or other plant residues, an attempt should be made to apply an amount equivalent to at least 10 tons of dry matter per acre.

If the material is loose and fluffy when placed in the furrows it may be compacted by driving over it some implement equipped with press wheels. Soon after application the organic materials should be covered by plowing out the intervening ridges to form beds over the materials, or by using a disk harrow or some other implement to cover the material and leave the land level for flat planting.

Irrigation water should be applied immediately so as to compact the soil and to encourage the activity of organisms for decomposition. If possible the organic material should be applied, covered, and irrigated at least a month before planting time, and a second irrigation should be made before planting to insure adequate moisture for germination of the cottonseed.

During the first 5 or 6 weeks of growth the cotton seedlings may show a slight yellowing of the leaves as a result of the concentrated manures in the predominant root zone. Usually this is not detrimental, and a bright green color and luxuriant growth may be expected as soon as the roots penetrate more deeply into the soil. However, if there is any evidence of browning along the edges of the leaves while the plants are young, a light irrigation usually will correct the burning and restore the plants to normal growing condition.

² KING, C. J., HOPE, C., and EATON, E. D. SOME MICROBIOLOGICAL ACTIVITIES AFFECTED IN MANURAL CONTROL OF COTTON ROOT ROT. *Jour. Agr. Research* 49: 1093-1107, illus. 1934.

EFFECTIVENESS OF ORGANIC MANURES IN REDUCING INFECTION
IN ARIZONA EXPERIMENTS

The first evidence that the use of organic manures was beneficial in reducing root rot infection was obtained from experiments conducted in the Salt River Valley in Arizona in 1918. The deep-furrow trench method of application was first tried at the United



FIGURE 2.—Freshly cut alfalfa applied in furrows at rate of 40 tons per acre for control of cotton root rot. Photographed January 14, 1935.

States Field Station at Sacaton in 1921 on a single quarter-acre plot which extended through the center of a badly infested block of nine plots comprising $2\frac{1}{4}$ acres. In 1923 the treatment was applied to three additional plots, leaving five alternate plots as controls. Three of the treated plots received corral manure at the rate of 12 tons per acre and one received green alfalfa at the rate of 15 tons per acre.

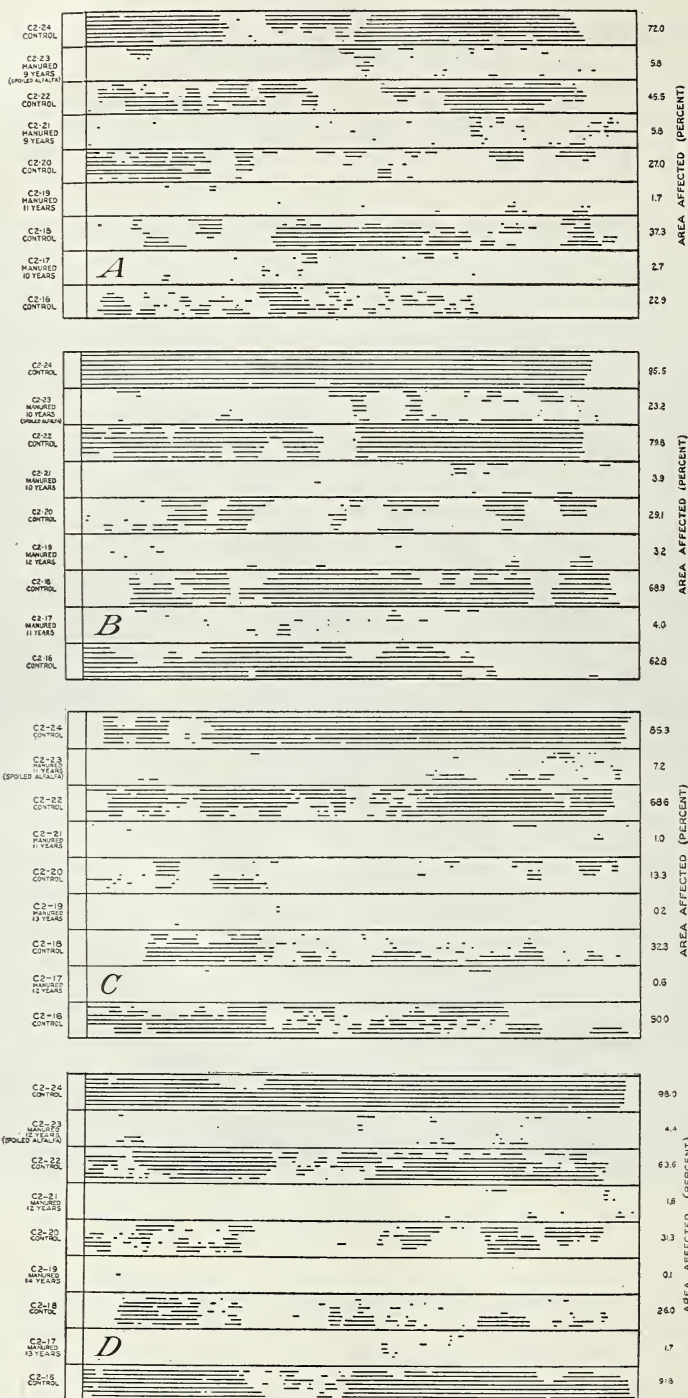


FIGURE 3.—Charts showing areas on which cotton plants were affected by root rot in manured and unmanured plots of block C2 at the United States Field Station, Sacaton, Ariz. A, 1932; B, 1933; C, 1934; and D, 1935.

With the exception of 1 or 2 years when manuring was omitted, the same procedure was followed until 1935. The quantities of manure, however, varied from 12 to 14 tons per acre and the alfalfa from 8 to 15 tons, depending on whether green alfalfa or spoiled alfalfa hay was used. Deep furrows also were made each year in the control plots, so that cultural conditions, other than manuring, would be comparable.

The effect of the treatment on reducing the extent of root rot infection in cotton is shown in figure 3. It will be noted that the proportion of plants affected³ in the three plots treated with corral manure was almost negligible during this period, and the plot treated with spoiled alfalfa was never seriously affected. In 1935 only 150, or 1.6 percent, of the plants died on the four treated plots, while the loss on the control plots was 7,041 plants, or 56.2 percent (figs. 4 and 5). The average annual yield per acre of Acala seed

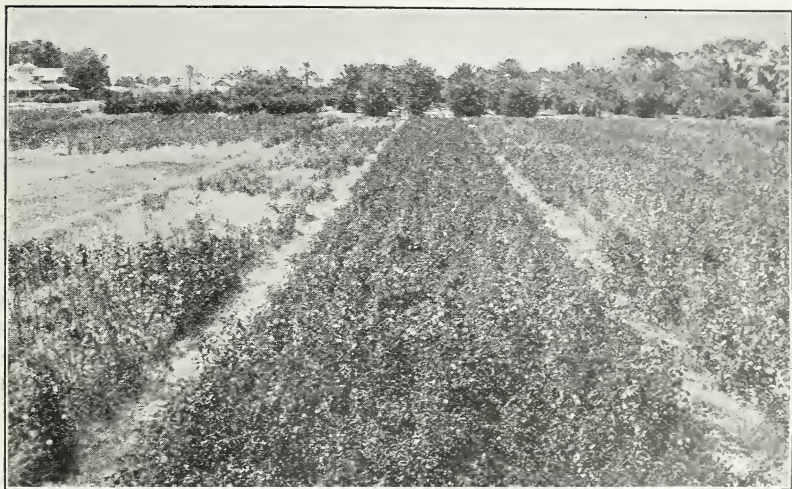


FIGURE 4.—Comparison of root rot damage in manured and unmanured plots of cotton. Center plot C2-17 received applications of corral manure for 13 years. Unmanured plots 16 and 18 at either side. View from north. Photographed October 24, 1935.

cotton on the manured plots for the 4-year period was 2,471 pounds, and for the five control plots 1,449 pounds. The combined yield from the control plots, expressed in percentage of yield from the manured plots, was 72, 54, 58, and 53 for 1932, 1933, 1934, and 1935, respectively.

A similar experiment with corral manure in deep furrows in alternate plots was begun on another portion of the experiment farm known as block B3 in 1934. At the end of the first year, plants were killed on 7 percent of the total area for the 8 treated plots and on 22 percent of the total area for the 13 untreated plots.

In 1935, after 2 years of treatment, plants were affected on 9 percent of the area for the treated plots and on 50 percent of the area

³ Plants affected with root rot seldom recover, hence the word "affected" indicates that the plants died or made no further fruiting development.

for the untreated plots. A map of the affected areas of 10 of these plots in 1935 is shown in figure 6.

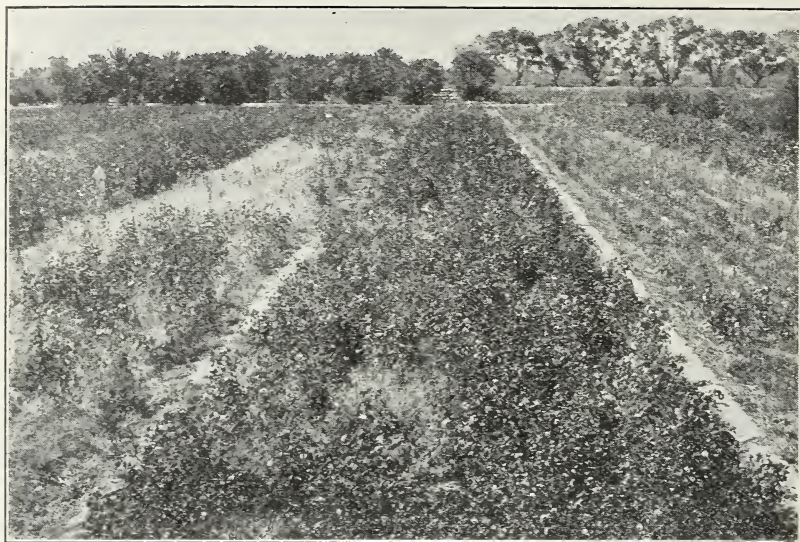


FIGURE 5.—Comparison of root rot damage in manured and unmanured plots of cotton. Center plot C2-23 received applications of spoiled alfalfa for 12 years. Unmanured plots 22 and 24 at either side. View from north. Photographed October 24, 1935.

From experiments in Arizona that have been in progress for only 1 or 2 years it is indicated that most of the leguminous plants that are commonly grown for cover crops and some of the wild growth

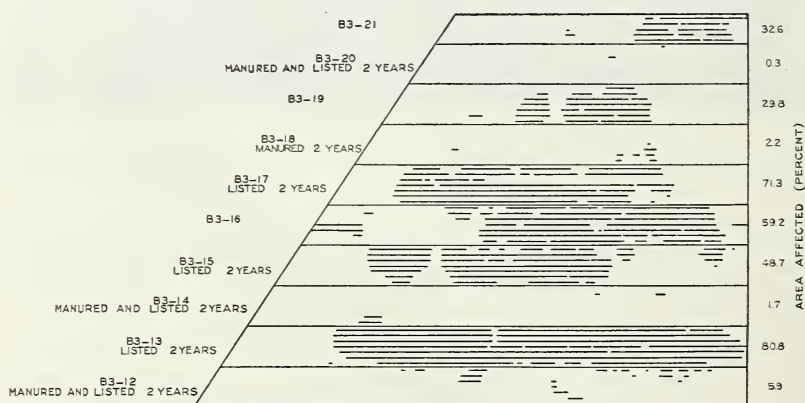


FIGURE 6.—Map showing area on which cotton plants were affected by root rot in nine plots of block B3 at the United States Field Station, Sacaton, Ariz., in 1935.

of mustards and mallows are suitable for furnishing organic matter to increase the microfloral populations that are effective in checking the activity of the root rot fungus.

Apparently the beneficial results of this treatment are due to the inability of the root rot fungus to thrive in the presence of great

numbers of bacteria, actinomycetes, and fungi that are actively engaged in decomposing the organic material. In 1933 tests were made to compare the activity of organisms in the various plots that had been manured since 1923 with that of the alternate unmanured plots. Carbon dioxide was given off at a much greater rate from the manured than from the unmanured plots, indicating a greater microfloral activity as a result of increasing the content of decomposing organic matter.

SUMMARY

A method is described which has proved effective for controlling root rot of cotton in Arizona. It consists in burying liberal quantities of organic manures in deep furrows in infested areas during the winter, irrigating to encourage rotting, and planting cotton over the decaying material in the spring. The control is more efficacious with successive treatments and should be continued over a period of years in order to build up and maintain an abundant microfloral population in the soil. The root rot fungus does not thrive in the presence of great activity on the part of saprophytic organisms, and the cotton plants frequently escape infection. The method should be applicable to row crops in any part of the irrigated region where root rot exists.

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